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The claims remaining in the application are 11-20.

REMARKS

The Applicants would like to thank the Examiner for the quick and courteous Office Action, and is appreciative of the Examiner's suggestions in overcoming some of the objections and rejections, and in particular the indication that claims 13-15 are objected to as being dependent upon a rejected base claim but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims. The Applicants also are grateful for the indication by the Examiner in items 3-6 on page 2 of the Action that various objections and rejections were overcome by Applicants' 09 July 2004 Amendment.

Minor Informalities

The Examiner objected to the disclosure because of the following informalities: In claim 16, "consisting" should be inserted after with "group" for proper Markush group language. Appropriate correction is required.

The Applicants greatly appreciate the Examiner pointing out this concern. The Examiner's attention is respectfully directed to the amendment to claim 16 where the word "consisting" has been inserted after the word "group" and before the word "of".

It is respectfully submitted that this amendment overcomes the minor informality objection to this claim. This change was made to correct an inadvertent clerical error and not for any substantial reason related to patentability. Reconsideration is respectfully requested.

35 U.S.C. §102(b) Rejection of Claims 11, 12, 19 and 20 over Roof

The Examiner has rejected claims 11, 12, 19 and 20 under 35 U.S.C. §102(b) as allegedly being anticipated by U.S. Pat. No. 5,552,060 to Roof. The Examiner notes that this rejection is analogous to that set forth in the 5/20/04 action, paragraph 8. The Examiner contends that Roof teaches abatement of hydrogen sulfide with epoxides, exemplifying several compositions reading upon these claims of applicants as now broadly recited

therein (referring to Roof Abstract and Examples 2, 4, 6-8 and 11). The Examiner notes that in particular, each Roof inventive example in Examples 2, 4, 6-8 and 11 shows a bottle comprising “hydrogen sulfide laden residual fuel oil (#6 oil)” that has been injected with one of the preferred Roof epoxides – styrene oxide, 1-3-butadiene diepoxide, or cyclohexane oxide (i.e. epoxides clearly within the scope of instant claims 11, 13-16, 19 and 20, as well as reading upon formula (II) of instant claim 12) – then stored in an oven at 121°C (referring to Roof Example 2, noting also col. 4, lines 11-13, 22-23). As 121°C is clearly at or above the melting point of sulfur (120°C), the Examiner contends that Roof thus exemplifies compositions containing “molten sulfur contaminated with at least one sulfhydryl compound” (i.e. applicants’ component a), as broadly recited in both independent claims 11 and 20), in concert with effective amounts of epoxide scavenging agents reading upon applicants’ formula (II); the Examiner further noting that Roof teaches molar ratios of scavenging agent to sulfhydryl compound (“proportional” or 1:1) which fall within the scope of applicants’ claim 20 range (referring to col. 3, lines 63-65). Also, the Examiner asserts that as Roof reports no color change for any of these exemplary compositions, the supposed “molten sulfur” is evidently “not discolored” as required by instant claim 19. Accordingly, the Examiner contends that Roof anticipates instant composition claims 11-16, 19 and 20, since compositions allegedly meeting all required limitations thereof are supposedly exemplified. The Examiner asserts that it is appreciated that these Roof examples are “hydrocarbon substrate” compositions “having the evolution of hydrogen sulfide therefrom inhibited”, whereas applicants’ claims recite “molten sulfur” compositions “having the evolution of hydrogen sulfide therefrom inhibited”. However, the Examiner asserts that applicants’ claims are clearly open to the presence of any additional component, including hydrocarbons, given the use of the transitional phrase “comprising” (referring to MPEP §2111.03). Moreover, the Examiner contends that this different preamble language does not patentably distinguish the instant composition claims from those compositions clearly disclosed by Roof, given that, again, these Roof compositions allegedly contain all required components in appropriate amounts, with the supposed first required component itself molten sulfur.

In paragraph 15 on page 11 of the Action, the Examiner responds to the Applicants’ arguments filed July 19, 2004 and notes that they have been fully considered, but

they have not been found persuasive. The Examiner finds that Applicants' essential argument appears to be that Roof fails to teach "molten sulfur", as required by all instant claims, hence Roof cannot anticipate nor have rendered *prima facie* obvious such claims, given that this key component is lacking from the Roof disclosure. However, the Examiner respectfully disagrees, since as shown by the two newly cited references, the specific fuel oil (#6 oil) used in the Roof examples relied upon above does in fact contain sulfur. In particular, the Examiner refers to the Dooher, et al. article, Table 1, which shows such "low sulphur" and "high sulphur" oils containing, respectively, 0.9 and 2.4 wt% sulfur, and U.S. Pat. No. 4,195,986 to Schulz, et al. which states that such oil has "1 to 5% sulfur content" (col. 1, lines 65-67). Accordingly, the Examiner maintains that since the Roof examples relied upon above are explicitly disclosed as having been stored in an oven at 121°C, with 121°C at or above the melting point of sulfur (120°C), Roof does in fact exemplify compositions containing "molten sulfur contaminated with at least one sulfhydryl compound" (i.e. applicant's component a), as broadly recited in both independent claims 11 and 20), in concert with effective amounts of epoxide scavenging agents reading upon Applicants' formula (II). The Examiner asserts that there is presently no evidence of record to indicate otherwise (i.e. that the sulfur present in these heated exemplary compositions would not have melted), and it is respectfully noted that "arguments of counsel cannot take the place of evidence in the record, citing *In re Schulze* and *In re Geisler*. The Examiner also acknowledges that Applicants argue that "elemental sulfur is known not to be a hydrocarbon (or to be aqueous for that matter). There is nothing in Roof that would suggest his epoxides would have any success with respect to molten sulfur". Insofar as the above rejections are made under 35 U.S.C. §102(b), the Examiner submits that there need be no such suggestion in Roof, given that, again, several examples are still considered to read on the instant claims, with the claims clearly open to all other components in #6 oil, in addition to (molten) sulfur. Insofar as the above rejections are made under 35 U.S.C. §103, the examiner disagrees, since the Roof teachings of how the epoxide is presumed to function as an H₂S scavenging agent are considered sufficient motivation for one of ordinary skill in the art to have incorporated same into compositions containing molten sulfur, at the time of Applicants' invention.

The Applicants must respectfully traverse.

A patent claim is anticipated, and therefore invalid, only when a single prior art reference discloses each and every limitation of the claim. *Glaxo Inc. v. Novopharm Ltd.*, 52 F.3d 1043, 1047, 34 U.S.P.Q.2d 1565 (Fed. Cir.), cert. denied, 116 S.Ct. 516 (1995).

All of the pending claims herein require molten sulfur, as that term is commonly understood in the industry, as part of the composition. The single Roof reference *does not* disclose this limitation of the claim. Because Roof does not teach *each and every limitation* of the claim, Roof does not anticipate any of the pending claims.

The term “molten sulfur” as used in the claims and specification herein simply has the meaning commonly used in the industry, which means predominantly elemental sulfur in the liquid or molten state, that is, its ordinary, customary meaning. To contend otherwise, the Applicants respectfully submit, does violence to the term and introduces confusion to the prosecution issues herein, it is respectfully submitted.

The Examiner’s attention is respectfully directed to the enclosed print-out from the Shell Canada World Wide Web site (http://www.shell.ca/code/products/exploration/sulphur/sulphur_product.html, 10/11/2004) which defines molten sulphur as being of 99.8 wt% purity. Also enclosed is a one-page sheet entitled “Sulfur Specifications – Current as of September 1, 1997” from Chalmet Refining that specifies molten sulfur to be 99.5% purity or greater. The Examiner’s attention is additionally directed to the following documents of record which understand that “molten sulfur” refers to a composition predominantly or primarily elemental sulfur in liquid or molten form as the term is customarily used:

<u>Pat. Document No.</u>	<u>Inventors</u>	<u>Pat. Document No.</u>	<u>Inventors</u>
US 4,299,811	Ledford, et al.	US 5,030,438	Voirin, et al.
US 4,313,922	Ledford, et al.	US 5,686,057	Witzig, et al.
US 4,423,025	Ledford, et al.	US 5,935,548	Franklin, et al.
US 4,478,811	Hass	WO 95/06616	Ellenor, et al.
Re. 32,009	Ledford, et al.	WO 97/29834	Plummer, et al.
US 5,004,591	Maurice, et al.		

The technical problem addressed in most, if not all of these documents is the same as that of the instant claims, namely inhibiting the evolution of H₂S from molten sulfur.

The Examiner supposes that Roof exemplifies compositions containing molten sulfur because the #6 fuel oil used in Examples 2, 4, 6-8 and 11 supposedly contains sulfur at a temperature that would make it molten, but this is incorrect, it is respectfully submitted. None of Roof's examples mention elemental, molten or liquid sulfur of any form, and indeed, molten and liquid sulfur and elemental sulfur are not mentioned in Roof at all. Roof's method and compositions are limited to sour aqueous and hydrocarbon substrates (please see *inter alia*, Roof's Abstract; column 1, lines 56-57; column 2, lines 10-13, and lines 33-56; and claim 1). The Applicants in particular note that Roof does not teach or suggest that his aqueous substrates and especially his hydrocarbon substrates (which would include #6 fuel oil) contain sulfur:

As used in this application, the term "aqueous substrate" refers to any "sour" aqueous substrate, including waste water streams in transit to or from, or contained in a municipal or other waste treatment facility, a tanning facility, a paper making facility, or a food processing facility.

The term "hydrocarbon substrate" is meant to include unrefined and refined hydrocarbon products, including natural gas, derived from petroleum or from the liquefaction of coal, both of which contain hydrogen sulfide or other sulfur-containing compounds. Thus, particularly for petroleum-based fuels, the term "hydrocarbon substrate" includes wellhead condensate as well as crude oil which may be contained in storage facilities at the producing field. "Hydrocarbon substrate" also includes the same materials transported from those facilities by barges, pipelines, tankers, or trucks to refinery storage tanks, or, alternately, transported directly from the producing facilities through pipelines to the refinery storage tanks. The term "hydrocarbon substrate" also includes refined products, interim and final, produced in a refinery, including distillates such as gasolines, distillate fuels, oils, and residual fuels. As used in the claims, the term "hydrocarbon substrate" also refers to vapors produced by the foregoing materials. [Column 2, lines 10-13, and lines 33-56]

Roof's Examples do not mention or note elemental sulfur. For this reason alone, it is respectfully submitted that the rejection must fall. The single reference does not disclose each and every limitation of the claim.

The Examiner attempts to rely upon the teachings of the Dooher, et al. article and U.S. Pat. No. 4,195,986 to Schulz, et al. for evidence of sulfur content in #6 oil. The Ex-

aminer has not made these documents the basis of a rejection. It is respectfully submitted that if the Examiner intends to rely on these documents, they should be made the basis of a rejection, as required by the Rules and the MPEP. (In such case, the instant rejection could not be based on 35 U.S.C. §102, but rather on 35 U.S.C. §103.) However, #6 fuel oil is not supposed to have sulfur in it as noted in the attached ASTM d 396-02a Standard Specification for Fuel Oils (November 2002, see particularly Table 1, page 2). It is respectfully submitted that Roof demonstrates this. A fuel oil is a petroleum product that consists predominantly or primarily of carbon, not elemental sulfur.

It is the Applicants' position that neither Dooher, et al., Schulz, et al. or Roof are proper references against the instant claims, since none of them relate to molten sulfur or the inhibiting of H₂S evolution therefrom. That is, it is respectfully submitted that all three of these documents are non-analogous art with respect to the instant claims. Non-analogous art is not properly prior art; the examiner cannot pick statements out of their proper context. *In re Pagliaro*, 657 F.2d 1219, 1225; 210 U.S.P.Q. 888, 892 (C.C.P.A. 1981). If the teaching is outside the art area, it must be shown that a person of ordinary skill would have considered it. *Ex parte Murphy and Burford*, 217 U.S.P.Q. 479, 482 (Bd. of App., 1982). It is respectfully submitted that the Examiner has not demonstrated why one having ordinary skill in the art of suppressing H₂S evolution from molten sulfur would look to patents such as Roof which are related to scavenging H₂S from hydrocarbon substrates *that contain no sulfur*.

The Examiner states, "There is presently no evidence of record to indicate otherwise (i.e. that the sulfur present in these heated exemplary compositions would not have melted) ...". However, it is respectfully submitted that it is the Examiner's assertion that there is sulfur present in Roof's hydrocarbon substrates in the first place that is factually unfounded. Roof does not teach the presence of sulfur. Dooher, et al. and Schulz, et al. are not relied upon and in any event are contradicted by ASTM D396-02a which specifies no sulfur in #6 fuel oil.

Applicants further respectfully note that the composition claims herein require that the *molten sulfur* composition contain *molten sulfur contaminated with at least one sulf-hydryl compound*. It is respectfully submitted that the Examiner has not shown where Roof discloses this limitation of the claim either, and cannot because Roof does not teach

molten sulfur to begin with. Much less does Roof teach molten sulfur (of which there is none) is contaminated with at least one sulfhydryl compound. To be complete, it is also noted that neither Dooher, et al. nor Schulz, et al. teach or suggest that the small amounts of sulfur in their #6 fuel oil is contaminated with at least one sulfhydryl compound.

The Examiner further alleges that because the pending claims are open due to the use of the transition phrase “comprising” that hydrocarbons could be included. The Applicants stipulate that while the claims are open, however, the fact remains that the pending claims recite and require molten sulfur and Roof does not even mention it. The fact that the claims are open does not permit the Examiner to assume that a reference teaches an element it does not. Using such reasoning, the Examiner could pick and choose any number of components from the prior art without regard for any link to the claimed process. “[T]he examiner has presented no line of reasoning ... as to why the artisan viewing only the collective teachings of the references would have found it obvious to selectively pick and choose various elements and/or concepts from the several references relied on to arrive at the claimed invention.” *Ex parte Clapp*, 227 U.S.P.Q. 972, 973 (B.P.A.I. 1985). It is respectfully submitted that the Examiner may not pick and choose from the reference only those portions which support her position. *In re Pagliaro*, 657 F.2d 1219, 1225; 210 U.S.P.Q. 888, 892 (C.C.P.A. 1981).

Thus, because Roof does not disclose this limitation of all of the claims, no proper rejection based on it has been made under 35 U.S.C. §102(b). Reconsideration is respectfully requested.

35 U.S.C. §102(b) or §103 Rejection of Claims 17 and 18 over Roof

The Examiner has again rejected claims 17 and 18 under 35 U.S.C. §102(b) as anticipated by or, in the alternative, under 35 U.S.C. §103 as obvious over Roof. The Examiner finds that this rejection is analogous to that set forth in the 5/20/04 action, paragraph 9. Roof is relied upon as immediately set forth above, allegedly anticipating applicants’ independent claim 11 (upon which claims 17 and 18 depend). Initially, the Examiner notes again that instant claims 17 and 18 are in product-by-process form, reciting the manner in which “the scavenging agent was incorporated into the molten sulfur”. The Examiner again contends that the Roof inventive examples in Examples 2, 4, 6-8 and 11

allegedly show compositions which appear to contain all components as required by instant claims 17 and 18 (noting that Roof teaches molar ratios of scavenging agent to sulfhydryl compound (“proportional” or 1:1) falling within the scope of applicants’ claim 17 range (referring again to col. 3, lines 63-65)). Thus, the Examiner contends that Roof may also be considered to anticipate claims 17 or 18, or, in the alternative, to have rendered compositions falling within their scope *prima facie* obvious, because:

[E]ven though product-by-process claims are limited by and defined by the process, determination of patentability is based on the product itself. The patentability of a product does not depend on its method of production. If the product in the product-by-process claim is the same as or obvious from a product of the prior art, the claim is unpatentable even though the prior product was made by a different process. *In re Thorpe*, 777 F.2d 695, 698, 227 USPQ 964, 966 (Fed. Cir. 1985). (MPEP §2113).

Alternatively then, if these Roof inventive examples fail in some way to meet the requirements of these two product-by-process claims, then, the Examiner contends that compositions falling within the scope thereof are allegedly *prima facie* obvious, since it would have been within the level of ordinary skill to have determined with minimum testing appropriate processes for making additional Roof compositions “having the evolution of hydrogen sulfide therefrom inhibited”. It is noted that the injection method exemplified by Roof could be considered “physically mixed”, per instant claim 17, and that Roof discusses the presence of H₂S in vapor phase above hydrocarbon substrate compositions, in accordance with instant claim 18.

The Examiner’s response to the Applicants’ arguments in the Amendment filed 09 July 2004 are also applicable with respect to this reference, and the Examiner mentions Dooher, et al. and Schulz, et al. in support of the rejection without explicitly relying upon them as would be proper.

The Applicants must again respectfully traverse.

Applicants stipulate the holding noted by the Examiner from *In re Thorpe*. However, Applicants again respectfully submitted that the rejections must fail for the same or similar reasons that the previous art rejection discussed above must fail.

As previously established, a patent claim is anticipated, and therefore invalid, *only* when a single prior art reference discloses each and every limitation of the claim. *Glaxo Inc. v. Novopharm Ltd., id.* (emphasis added) Rejected dependent claims 17 and 18, by virtue of their dependency on claim 11, require and recite the presence of molten sulfur. Roof does not disclose, teach or suggest this limitation of the claims. Therefore Roof does not anticipate claims 17 and 18, it is respectfully submitted. Contrary to the Examiner's supposition, Roof's Examples *do not* contain all components required by claims 17 and 18: they *do not* contain molten sulfur or elemental sulfur in any form, for that matter.

Furthermore, Roof does not teach or suggest molten sulfur contaminated with at least one sulfhydryl compound in the composition as required by all of the pending claims, including dependent claims 17 and 18. This is because Roof does not teach or suggest molten sulfur or even elemental sulfur.

As previously established, it is respectfully submitted that to supposedly find "molten sulfur" in Roof does violence to and contradicts the ordinary and simple meaning of that term as used in the industry and by those of ordinary skill in the art. "Molten sulfur" refers to predominantly liquid or molten elemental sulfur, as established by the Shell Canada and Chalmet Refining specifications, as well as by many of the patent documents already of record, previously noted. It is respectfully submitted that one having ordinary skill in the art knowing the term "molten sulfur" would not apply that term to small amounts (especially non-existent amounts) of sulfur in #6 fuel oil.

Additionally, it is respectfully submitted that claims 17 and 18 are not obvious from the teachings of Roof. To support an obviousness rejection, the Examiner has the initial burden of establishing a *prima facie* case of obviousness of the pending claims over the cited prior art, *In re Oeticker*, 977 F.2d 1443, 1445; 24 U.S.P.Q.2d 1443 (Fed. Cir. 1992). It is respectfully submitted that the Examiner has not met this initial burden here. The Examiner has not established why one having ordinary skill in the art would know only from Roof that *molten sulfur* having the scavenging agents of this invention would have hydrogen sulfide evolution inhibited therefrom. Roof is completely silent about molten sulfur and does not mention or hint at it in any way. Roof also does not teach or suggest molten sulfur contaminated with at least one sulfhydryl compound, as required by claims 17 and 18, via dependency.

A *prima facie* case must be put forward by the Examiner; missing facts cannot be assumed, *Ex parte Wolters*, 214 U.S.P.Q. 735 (Bd. App. 1979). It is further respectfully submitted that missing facts cannot be assumed with respect to a proper anticipation rejection based on 35 U.S.C. §102(b) either. Here the Examiner assumes the necessary limitation and presence of elemental sulfur, particularly molten sulfur, where there is no support in the reference relied upon for its presence. Silence in the reference is not a proper substitute for a disclosure of facts adequate enough to support a conclusion of obviousness, *In re Burt*, 148 U.S.P.Q. 548, 553 (C.C.P.A. 1966). The Applicants respectfully submit that here the Examiner has assume that Roof's hydrocarbon substrates contain molten sulfur when it does not.

In re Chu, 66 F.3d 292, 298, 36 U.S.P.Q.2d 1089 (Fed. Cir. 1995), instructs that to properly determine obviousness, even "minor" changes from the prior art must be evaluated in terms of the entire invention, *including whether the prior art provides any teaching or suggestion to one of ordinary skill in the art to make the "minor" changes* that would produce the patented invention. The suggestion or motivation to make the claimed invention "leaps at a person of ordinary skill in the art from thorough inspection" of a complete prior art device, *Para-Ordnance Manufacturing, Inc. v. SGS Importers International, Inc.*, 73 F.3d 1085, 1090, 37 U.S.P.Q. 1237, 1241 (Fed. Cir. 1995). It is respectfully submitted that the suggestion to substitute molten sulfur for the hydrocarbon or aqueous substrates of Roof does not "leap" to one having ordinary skill in the art since the reference does not even mention molten sulfur once.

"The mere fact that the prior art could be so modified would not have made the modification obvious unless the prior art *suggested the desirability of the modification*." *In re Gordon*, 733 F.2d 900, 902, 221 U.S.P.Q. 1125, 1127 (Fed. Cir. 1984) cited in *In re Mills*, 916 F.2d 680, 16 U.S.P.Q.2d 1430 (Fed. Cir. 1990), in turn cited by MPEP §2143.01 (emphasis added). There is nothing in the Roof prior art that suggests the desirability of modifying the Roof teaching to replace hydrocarbon or aqueous substrates with molten sulfur. Nor is there anything in Schulz, et al. or Dooher, et al. (which the Examiner does not rely upon) for this substitution.

Elemental sulfur is known not to be a hydrocarbon (or to be aqueous, for that matter). There is nothing in Roof that would suggest his epoxides would have any success

with respect to molten sulfur. "The teaching or suggestion to make the claimed combination *and* reasonable expectation of success must both be found in the prior art, not in applicant's disclosure. *In re Vaeck*, 947 F.2d 488, 493, 20 U.S.P.Q.2d 1438, 1442 (Fed. Cir. 1991)." (MPEP §2143, emphasis added.) It is respectfully submitted that here *neither* the teaching or suggestion to make the modification *nor* any expectation of its success is present in Roof. Consequently, it is respectfully submitted that a *prima facie* rejection of obviousness of claims 17 and 18 based on Roof has not been made.

Applicants further respectfully submit that Roof is improperly cited and not analogous to the art of the claimed invention, and that neither are Schulz, et al. or Dooher, et al. for reasons previously established to which the Examiner's attention is respectfully directed. None of these documents concern molten sulfur as that term is commonly and routinely understood in the relevant art.

It is further respectfully submitted that all of the arguments and distinctions established with respect to the immediate previous rejection are equally applicable here, and the Examiner's attention is respectfully directed thereto to avoid repeating them here for the sake of brevity in an already lengthy response. Since neither a 35 U.S.C. §102(b) rejection nor a 35 U.S.C. §103(a) rejection have been properly made, claims 17 and 18 are patentable over Roof. Reconsideration is respectfully requested.

35 U.S.C. §102(b) and 35 U.S.C. §103(a) Rejections of Claims 11, 16, and 19 over Plummer

The Examiner has rejected claims 11, 16 and 19 under 35 U.S.C. §102(b) as allegedly anticipated by or, in the alternative, under 35 U.S.C. §103 as allegedly obvious over WO 97/29834 to Plummer, et al. The Examiner finds that Plummer, et al. teach:

A process for removing liquid sulfur from a reaction mixture during a gas treating process, especially a process for removing hydrogen sulfide from a gaseous stream. **Sulfur which is formed during the process is removed from a reaction mixture by first concentrating the sulfur in a small portion of the reaction mixture and then heating this portion to a temperature which is sufficient to melt the sulfur.** The molten sulfur is removed from the reaction mixture and washed with a suitable solvent to remove any remaining reaction mixture. (Plummer, et al. Abstract emphasis added)

Furthermore, Plummer, et al. claim 1 recites:

A process for converting hydrogen sulfide to sulfur comprising:
contacting a feed gas containing hydrogen sulfide with a polar organic solvent having a quinone dissolved therein, said hydrogen sulfide reacting with said quinone to produce sulfur and a hydroquinone in said solvent;
concentrating said sulfur in a portion of said polar organic solvent;
heating said portion of said solvent to a temperature sufficient to melt said sulfur; and
removing said molten sulfur from said polar organic solvent. (emphasis added)

and, in claim 21, Plummer, et al. specifically recite that the “polar organic solvent” may be “propylene carbonate” – namely, a carbonate which falls within the scope of Applicants’ structural formula (V), as recited in instant claim 16. In addition, as Plummer, et al. report no color change occurring within the disclosed processes, the “molten sulfur” is evidently “non discolored” as required by instant claim 19. Accordingly, Plummer, et al. allegedly anticipates instant composition claims 11, 12, and 19 since compositions meeting all required limitations thereof are contended to be taught via the Plummer, et al. claims. The Examiner also notes that the amount of sulfur and “polar organic solvent” in the “portion” shown in Plummer, et al. Example 1 (i.e., 49.33 g sulfur and about 0.49 g NMP, giving about 1 wt% NMP) are on the order of those used in instant Examples 1-12 (i.e. about 0.05 wt% scavenging agents), Plummer, et al. are alleged to meet the “effective amount” requirement of Applicants’ independent claim 11. Alternatively, the Examiner concedes that it could be argued that Plummer, et al. do not fully anticipate these claims of Applicants since the use of propylene carbonate as the “polar organic solvent” is admitted as not exemplified (Plummer, et al. Example 1 on p. 7). However, the Examiner contends that even if not anticipated, then she alleges that the compositions falling within the scope of instant claims 11, 16 and 19 are considered to have been *prima facie* obvious to one of ordinary skill in the art at the time of the Applicants’ invention, because, as just discussed, the broad teachings of Plummer, et al. allegedly encompass where such compositions are implicitly disclosed (again, via Plummer, et al. claim 21). Lastly, the Examiner admits that Plummer, et al.’s claims are directed towards processes for converting hydrogen sulfide to sulfur, where Applicants’ claims recite “molten sulfur” compositions “hav-

ing the evolution of hydrogen sulfide therefrom inhibited”. However, the Examiner notes that Applicants’ claims are open to the presence of any additional component, including the additional components recited in Plummer, et al. claim 1, given the use of the transitional phrase “comprising”. Moreover, the Examiner contends that this different preamble language does not patentably distinguish the instant composition claims from those compositions at least implicitly disclosed in the Plummer, et al. claims – particularly Plummer, et al. claim 21 – given that, again such compositions appear to contain all required components in appropriate amounts, with the first required component itself molten sulfur.

The Applicants must respectfully traverse.

The Examiner’s attention is respectfully directed to the amendments to claims 11, 16 and 20 herein where cyclic carbonates are now excluded. The single carbonate taught by Plummer, et al. propylene carbonate, is a cyclic carbonate. Claims 11 and 20 have been explicitly amended to recite linear carbonates. Support for linear carbonates is found in the application as filed on page 6, line 38, the first line in paragraph [0024], and thus this inclusion does not constitute an improper insertion of new matter.

Because Plummer, et al. does not disclose linear carbonates, and thus does not disclose each and every limitation of the claims as amended, the amended claims are novel over the reference. Further, because Plummer, et al. does not teach or suggest linear carbonates, it is respectfully submitted that the amended claims are not obvious therefrom.

In Plummer, et al., the stream containing polar organic solvent actually contains sulfur, indeed concentrated sulfur, unlike the hydrocarbon and aqueous substrates of Roof.

Reconsideration is respectfully requested.

35 U.S.C. §103(a) Rejection of Claims 11, 12, and 16-20 over “Instant Specification” in view of Roof

The Examiner has rejected claims 11, 12, and 16-20 under 35 U.S.C. §103(a) as allegedly being unpatentable over the instant specification, pages 1-2, paragraphs [0002]-[0006] and [0008], in view of Roof. The Examiner notes that this rejection is somewhat

similar to that set forth in the parent application, paper no. 4 therein. In the "Background of the Invention" section of the instant specification, the Applicants state:

[0005] The problem of removing or reducing H_2S from molten sulfur has been solved in many different ways in the past. Oxidizers such as sodium or calcium hypochlorite or hypobromite have been used as scavengers in liquid sulfur. Air has also been used as an oxidizer to convert H_2S to elemental sulfur.

[0006] Other approaches involve intentionally promoting the evolution or degassing of H_2S from the molten sulfur. That is, various additives are used to intentionally cause sulfhydryl species such as $H-S-(S)_x-S-H$ to decompose. The H_2S formed is then swept away to a vapor recovery system. Once these materials are decomposed, the sulfur is left with reduced potential to form more H_2S and may be relatively safer to transport. Typical compounds used in such methods contain nitrogen.

Accordingly, based upon Applicants' contended, admitted prior art as cited above (as per MPEP §2129), the need to remove or reduce H_2S from molten sulfur, as well as methods of doing same by use of various additives were, again, allegedly known in the prior art at the time of Applicants' invention. However, such use of epoxides, including those of Applicants' structural formula (I), as specifically recited in instant claim 12, is **not** acknowledged by the Applicants as admitted prior art.

As discussed in paragraph 8 above, the Examiner contends that Roof teaches abatement of hydrogen sulfide with epoxides, preferring and exemplifying the use of three epoxides, i.e. styrene oxide, 1-3-butadiene diepoxide, and cyclohexane oxide, which are within the scope of instant claims 11 and 20, and which also fall within the scope of Applicants' claim 12 structural formula (II). After acknowledging that "[t]he removal of H_2S from a liquid or gaseous hydrocarbon stream is a problem that has challenged many workers in many industries" (col. 1, lines 14-16), Roof goes on to teach:

The scavenging agents of the present invention are epoxides. Without limiting the invention to any particular theory, the epoxide portion of the molecule is believed to react with the sulfhydryl compounds ... Any epoxide should function in the present invention as long as the remainder of the compound does not interfere with this reaction. ... [and]

The epoxide portion of the molecule is believed to be the functional group that actually reacts with the sulfur moiety; therefore, molecules in which the epoxide group is more "accessible" to the sulfur in the substrate

should be more efficient scavengers. (col. 2, line 56 to col. 3, line 3, and col. 3, lines 24-28)

The Examiner asserts that therefore it would have allegedly been obvious to one of ordinary skill in the art, at the time of the Applicants' invention, to have added any of the epoxides of Roof to molten sulfur in need of H₂S removal/reduction (again, acknowledged by Applicants as alleged admitted prior art), because, as discussed, Roof teaches that such epoxides function as H₂S scavenging agents by, presumably, reaction of the epoxide portion of such molecules with the H₂S sulfur moiety. When having done so, the Examiner submits that, absent contrary evidence, compositions falling within the scope of instant claims 11, 12 and 16-20 would have allegedly obviously resulted, noting again that: 1) Roof teaches molar ratios of scavenging agent to sulfhydryl compound ("proportional" or 1:1) falling within the scope of Applicants' claim 17 and claim 20 range (col. 3, lines 63-65); 2) the injection method exemplified by Roof could be considered "physically mixed", per instant claim 17; 3) Roof discusses the presence of H₂S in vapor phase above hydrocarbon substrate compositions (col. 3, lines 43-65), per instant claim 18; and 4) as the Roof preferred epoxides fall within the scope of Applicants' claim 12 structural formula (II), the combination of such epoxides with molten sulfur would have obviously "not discolored" the sulfur, per instant claim 19.

The Applicants must respectfully traverse. Applicants respectfully submit that this rejection is deficient for reasons similar to those why the rejection in paragraph 8 of the instant Action is deficient.

To support an obviousness rejection, the Examiner has the initial burden of establishing a *prima facie* case of obviousness of the pending claims over the cited prior art, *In re Oeticker, id.* Applicants respectfully submit that a *prima facie* case of obviousness has not been made herein. "The teaching or suggestion to make the claimed combination *and* reasonable expectation of success must both be found in the prior art, not in applicant's disclosure. *In re Vaeck, id.*" (MPEP §2143, emphasis added.) It is respectfully submitted that here *neither* the teaching or suggestion to make the modification *nor* any expectation of its success is present in the supposed "admitted prior art" together with Roof. It is respectfully submitted that the Examiner has not answered why one having *ordinary* skill

in the art would expect Roof's epoxides to successfully inhibit the evolution of H₂S from molten sulfur, when all that Roof teaches is a method for *scavenging* H₂S from aqueous or hydrocarbon substrates that do not contain sulfur.

Applicants respectfully submit that the alleged "admitted prior art" in paragraphs [0002]-[0006] and [0008] of the subject application are nothing more than a statement of the technical problem addressed by the instant claimed invention, namely inhibiting the evolution of H₂S from molten sulfur. As established previously, and particularly with respect to the rejection in paragraph 8 of the subject rejection herein, Roof does not teach or address or concern molten sulfur in any fashion, much less the inhibition of H₂S evolution therefrom. Roof only concerns scavenging H₂S from aqueous and hydrocarbon substrates. None of the hydrocarbon substrates are taught to contain sulfur or molten sulfur.

Thus, the combination of the supposed admitted prior art with Roof does not teach or suggest making the claimed combination. There is no reason for one having ordinary skill in the art to think to use the Roof epoxides to inhibit the evolution of H₂S from *molten sulfur*, particularly since Roof is silent on the topic, and since paragraphs [0002]-[0006] and [0008] of the specification herein do not mention epoxides. Further, there is no reasonable expectation that such a combination would succeed at inhibiting H₂S evolution since the suggestion of such a combination is non-existent.

At most, the combination of the supposed admitted prior art with Roof would be "obvious to try" – which is not a proper standard of obviousness. "Obvious to try" has long been held not to constitute obviousness, *In re O'Farrell*, 853 F.2d 894, 903, 7 U.S.P.Q.2d 1673, 1680-81 (Fed. Cir. 1988). A general incentive does not make obvious a particular result, nor does the existence of techniques by which those efforts can be carried out, *In re Deuel*, 51 F.3d 1552, 1559, 34 U.S.P.Q.2d 1210 (Fed. Cir. 1995). "Obvious to try" is not the proper standard under 35 U.S.C. §103, *In re Fine*, 5 U.S.P.Q.2d 1596, 1599 (Fed. Cir. 1988). Roof only teaches using his epoxides to scavenge H₂S from aqueous or hydrocarbon substrates – and not even substrates containing molten sulfur since there is no evidence in Roof that the hydrocarbon substrates therein contained sulfur.

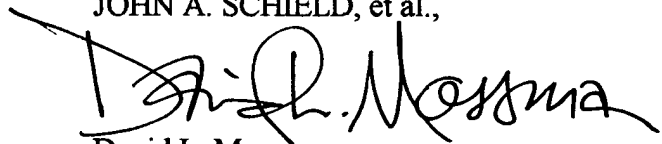
It is respectfully submitted that using the Examiner's reasoning, any application containing a description of the technical problem addressed by the invention would allegedly be obvious. The presence in the instant application of a statement of the technical

problem does not add any additional authority or teaching to Roof which, as settled, fails to anticipate, teach or suggest the claimed invention.

It is respectfully submitted that for all of these reasons, a prima facie rejection for obviousness has not been made for the instant claims over the combination of Roof with the supposed "admitted prior art". Reconsideration is respectfully requested.

It is respectfully submitted that the amendments and arguments presented above place the claims in condition for allowance. Reconsideration and allowance of the claims, as amended, are respectfully requested. The Examiner is respectfully reminded of her duty to indicate allowable subject matter. The Examiner is invited to call the Applicants' attorney at the number below for any reason, especially any reason that may help advance the prosecution.

Respectfully submitted,
JOHN A. SCHIELD, et al.,

A handwritten signature in black ink, appearing to read "David L. Mossman", is written over a horizontal line.

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Products

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Our Product

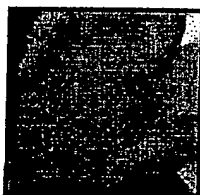
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Our Production Base:

The sulphur produced at gas plants in Central Alberta results from the processing of natural gas containing hydrogen sulfides or "sour" gas. Using state-of-the-art sulphur recovery technology, hydrogen sulfide is converted into sulphur.

"Sour" gas is common in deep natural gas deposits in Alberta. Almost 90 percent of all elemental sulphur produced in Canada comes from sour natural gas processing. The rest comes from oil refineries and oil sands plants.

Rotoform® Pastilles:



Sulphur produced by Shell is available as both formed and molten product. The majority of our product is produced as Rotoform which Shell has been instrumental in pioneering. Our Sandvik Rotoform pastilles form is the latest generation of a premium sulphur product. The many desirable characteristics of Rotoform have made it a popular choice in markets

around the world.

Rotoform Description:

Rotoform pastilles have a lot in common with miniature chocolate chips. In fact they are formed with the same type of equipment. This produces a product that is uniform in size and density. This offers many advantages to the end user.

- It allows for even burn rates. With virtually identical pastilles, the melting process occurs in a consistent fashion.
- Made of a durable crust, they are resistant to breaking which reduces the likelihood of dust escaping from the product. Having no edges or corners to break off, eliminates environmental and safety handling problems.
- Rotoform Pastilles enables seamless storage, handling, and processing. They can be more efficiently and accurately measured, which increases their economic contribution.
- Product loss due to moisture and acidity are reduced due to its uniform shape and compression.



*Sandvik Process Systems Inc. Rotoform®
premium pastilles produced at Shantz*

Technical Data Sheet:

	% By Weight
Total Sulphur	99.8 plus
Ash	<.05
Arsenic	Commercially free
Carbon	<.05
Selenium	Commercially free
Tellurium	Commercially free
Colour	Bright yellow
Particle size	99.5% 3.5 - 4.2 mm diameter
Density	1120 – 1200 Kg/M3
Angle of repose	28 Degrees

Molten Sulphur:

Ninety percent of all sulphur sold to U.S. markets is shipped in "molten" or liquid form. Sulphur in molten form is a practical, environmental, and economic method of shipping. Liquid sulphur is normally handled between 132-143 degrees C (270-290 degrees F). It is transported in insulated rail cars, which are equipped with heating coils. These coils act to remelt any sulphur that solidifies while the sulphur is in transit so complete unloading can occur.



Rapid loading of unit trains of molten sulphur at Shell Canada's Waterton Gas Plant

Shell Canada Liquid Sulphur Specifications:

	% By Weight
Total Sulphur	99.8 plus
Carbon	<.05
Ash	<.05
Arsenic	Commercially free
Selenium	Commercially free
Tellurium	Commercially free

Comments or questions about Shell Canada or Shell Canada's website?
Please contact us at: questions@shell.com

Evelyn Ponton - X-1617

Chalmet
Refining

SULFUR SPECIFICATIONS

Current as of September 1, 1997

Component	Unit	MFG Spec	Acceptable Test Procedure
<u>Primary</u>			
Acidity as H2SO4	ppm	<10	ASTM D4569 ⁽¹⁾
Ash	ppm	<30	ASTM D4574 ⁽²⁾
Carbon	ppm	<500	Texasgulf Manual ⁽³⁾
Purity	Percent	>99.5	100%-Acidity-Ash-Carbon
<u>Secondary</u>			
* H2S ⁽⁴⁾ (in liquid)	ppm	<40	Multi-tube Kitigawa
Melting Point ⁽⁵⁾	°C	112.8°C-121°C	International Sulphur Specification
Vanadium ⁽⁶⁾	ppm	<2	Elemental AA spectroscopy
Sodium ⁽⁶⁾	ppm	<2	Elemental AA spectroscopy
Arsenic ⁽⁶⁾	ppm	<2	Elemental AA spectroscopy
Tellurium ⁽⁶⁾	ppm	<2	Elemental AA spectroscopy
Selenium ⁽⁶⁾	ppm	<10	Elemental AA spectroscopy
Chloride ⁽⁶⁾	ppm	<10	Elemental AA spectroscopy
Fluorine ⁽⁶⁾	ppm	<1	Texasgulf Manual ⁽³⁾
			Ion Specific Electrode

- 1) Modified to allow use of a combination electrode
- 2) Modified to allow sample size from 5 grams to 500 grams, with an inert dish sized for the sample
- 3) 1959 Edition
- 4) H2S Test only required for marine moves: Test only molten sulfur captured in a closed container. FTIR is not yet approved for product certification: waiting for calibration procedure to be developed
- 5) Melting point only required by International Sulphur
- 6) Tested upon customer request or mutually agreed schedule

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* Dick to develop full cost case for refineries

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Standard Specification for Fuel Oils¹

This standard is issued under the fixed designation D 396; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This specification (Note 1) covers grades of fuel oil intended for use in various types of fuel-oil-burning equipment under various climatic and operating conditions. These grades are described as follows:

1.1.1 Grades 1, 1 Low Sulfur, 2, and 2 Low Sulfur are middle distillate fuels for use in domestic and small industrial burners. Grades 1 and 1 Low Sulfur are particularly adapted to vaporizing type burners or where storage conditions require low pour point fuel.

1.1.2 Grades 4 (Light) and 4 are heavy distillate fuels or distillate/residual fuel blends used in commercial/industrial burners equipped for this viscosity range.

1.1.3 Grades 5 (Light), 5 (Heavy), and 6 are residual fuels of increasing viscosity and boiling range, used in industrial burners. Preheating is usually required for handling and proper atomization.

Note 1—For information on the significance of the terminology and test methods used in this specification, see Appendix X1.

Note 2—A more detailed description of the grades of fuel oils is given in X1.3.

1.2 This specification is for the use of purchasing agencies in formulating specifications to be included in contracts for purchases of fuel oils and for the guidance of consumers of fuel oils in the selection of the grades most suitable for their needs.

1.3 Nothing in this specification shall preclude observance of federal, state, or local regulations which can be more restrictive.

1.4 All values are stated in SI units and are regarded as standard.

Note 3—The generation and dissipation of static electricity can create problems in the handling of distillate burner fuel oils. For more information on the subject, see Guide D 4865.

2. Referenced Documents

2.1 ASTM Standards:

¹ This specification is under the jurisdiction of ASTM Committee D02 on Petroleum Products and Lubricants and is the direct responsibility of Subcommittee D02.E0.01 on Burner Fuels.

Current edition approved Nov. 10, 2002. Published November 2002. Originally published as D 396–34T. Last previous edition D 396–02.

- D 56 Test Method for Flash Point by Tag Closed Tester²
- D 86 Test Method for Distillation of Petroleum Products at Atmospheric Pressure²
- D 93 Test Methods for Flash Point by Pensky-Martens Closed Cup Tester²
- D 95 Test Method for Water in Petroleum Products and Bituminous Materials by Distillation²
- D 97 Test Method for Pour Point of Petroleum Products²
- D 129 Test Method for Sulfur in Petroleum Products (General Bomb Method)²
- D 130 Test Method for Detection of Copper Corrosion from Petroleum Products by the Copper Strip Tarnish Test²
- D 445 Test Method for Kinematic Viscosity of Transparent and Opaque Liquids²
- D 473 Test Method for Sediment in Crude Oils and Fuel Oils by the Extraction Method²
- D 482 Test Method for Ash from Petroleum Products²
- D 524 Test Method for Ramsbottom Carbon Residue of Petroleum Products²
- D 975 Specification for Diesel Fuel Oils²
- D 1266 Test Method for Sulfur in Petroleum Products (Lamp Method)²
- D 1298 Test Method for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method²
- D 1552 Test Method for Sulfur in Petroleum Products (High-Temperature Method)²
- D 2500 Test Method for Cloud Point of Petroleum Products²
- D 2622 Test Method for Sulfur in Petroleum Products by Wavelength Dispersive X-Ray Fluorescence Spectrometry²
- D 2709 Test Method for Water and Sediment in Middle Distillate Fuels by Centrifuge²
- D 3245 Test Method for Pumpability of Industrial Fuel Oils³
- D 3828 Test Methods for Flash Point by Small Scale Closed Tester³
- D 4052 Test Method for Density and Relative Density of Liquids by Digital Density Meter³

² Annual Book of ASTM Standards, Vol. 05.01.

³ Annual Book of ASTM Standards, Vol. 05.02.

TABLE 1 Detailed Requirements for Fuel Oils^A

Property	ASTM Test Method ^B	No. 1 Low Sulfur ^C	No. 1 ^C	No. 2 Low Sulfur ^C	No. 2 ^C	Grade No. 4 (Light) ^C	No. 4	No. 5 (Light)	No. 5 (Heavy)	No. 6
Flash Point °C, min	D 93 - Proc. A D 93 - Proc. B	38 ...	38 ...	38 ...	38 ...	38...	...	...	...	...
Water and sediment, % vol, max	D 2709 D 95 + D 473 D 88	0.05 ...	0.05 ...	0.05 ...	0.05 ...	...	55 (0.50) ^D	55 (1.00) ^D	55 (1.00) ^D	60 (2.00) ^D
Distillation temperature °C										
10 % volume recovered, max		215	215	...	...	...	...	...	...	...
90 % volume recovered, min		...	...	282	282	...	...	...	...	...
90 % vol recovered, max		288	288	338	338	...	...	...	...	...
Kinematic viscosity at 40°C, mm ² /s	D 445									
min		1.3	1.3	1.9	1.9	1.9	>5.5	...	...	...
max		2.1	2.1	3.4	3.4	5.5	24.0 ^E	...	...	...
Kinematic viscosity at 100°C, mm ² /s	D 445									
min		...	...	...	...	...	...	5.0	9.0	15.0
max		...	...	...	...	...	...	8.9 ^E	14.9 ^E	50.0 ^E
Ramsbottom carbon residue on 10 % distillation residue % mass, max	D 524	0.15	0.15	0.35	0.35	...	...	...	...	...
Ash, % mass, max	D 482	...	...	...	...	0.05	0.10	0.15	0.15	...
Sulfur, % mass max ^F	D 129 D 2622	...	0.50	...	0.50	...	...	...	...	...
Copper strip corrosion rating, max, 3 h at 50°C	D 130	No. 3	No. 3	No. 3	No. 3	...	...	...	...	...
Density at 15°C, kg/m ³	D 1298									
min		...	...	...	...	>876 ^G	...	...	...	...
max		850	850	876	876	...	...	...	...	...
Pour Point °C, max ^H	D 97	-18	-18	-6	-6	-6	-6	...	...	...

^A It is the intent of these classifications that failure to meet any requirement of a given grade does not automatically place an oil in the next lower grade unless in fact it meets all requirements of the lower grade. However, to meet special operating conditions, modifications of individual limiting requirements may be agreed upon among the purchaser, seller, and manufacturer.

^B The test methods indicated are the approved referee methods. Other acceptable methods are indicated in Section 2 and 5.1.

^C Under United States regulations, Grades No. 1, No. 1 Low Sulfur, No. 2, No. 2 Low Sulfur, and No. 4 (Light) are required by 40 CFR Part 80 to contain a sufficient amount of the dye Solvent Red 164 so its presence is visually apparent. At or beyond terminal storage tanks, they are required by 26 CFR Part 48 to contain the dye Solvent Red 164 at a concentration spectrally equivalent to 3.9 lb per thousand barrels of the solid dye standard Solvent Red 26.

^D The amount of water by distillation by Test Method D 95 plus the sediment by extraction by Test Method D 473 shall not exceed the value shown in the table. For Grade No. 6 fuel oil, the amount of sediment by extraction shall not exceed 0.50 mass %, and a deduction in quantity shall be made for all water and sediment in excess of 1.0 mass %.

^E Where low sulfur fuel oil is required, fuel oil falling in the viscosity range of a lower numbered grade down to and including No. 4 can be supplied by agreement between the purchaser and supplier. The viscosity range of the initial shipment shall be identified and advance notice shall be required when changing from one viscosity range to another. This notice shall be in sufficient time to permit the user to make the necessary adjustments.

^F Other sulfur limits may apply in selected areas in the United States and in other countries.

^G This limit ensures a minimum heating value and also prevents misrepresentation and misapplication of this product as Grade No. 2.

^H Lower or higher pour points can be specified whenever required by conditions of storage or use. When a pour point less than -18°C is specified, the minimum viscosity at 40°C for grade No. 2 shall be 1.7 mm²/s and the minimum 90 % recovered temperature shall be waived.

^I Where low sulfur fuel oil is required, Grade No. 6 fuel oil will be classified as Low Pour (+15°C max) or High Pour (no max). Low Pour fuel oil should be used unless tanks and lines are heated.

D 4057 Practice for Manual Sampling of Petroleum and Petroleum Products³

D 4294 Test Method for Sulfur in Petroleum and Petroleum Products by Energy-Dispersive X-Ray Fluorescence Spectrometry³

D 4865 Guide for Generation and Dissipation of Static Electricity in Petroleum Fuel Systems³

D 5453 Test Method for Determination of Total Sulfur in Light Hydrocarbons, Motor Fuels and Oils by Ultraviolet Fluorescence⁴

D 5949 Test Method for Pour Point of Petroleum Products (Automatic Pressure Pulsing Method)⁴

D 5950 Test Method for Pour Point of Petroleum Products (Automatic Tilt Method)⁴

D 5985 Test Method for Pour Point of Petroleum Products (Rotational Method)⁴

D 6469 Guide to Microbial Contamination in Fuels and Fuel Systems⁵

2.2 Other Documents:⁶

26 CFR Part 48 Diesel Fuel Excise Tax; Dye Color and Concentration

40 CFR Part 80 Regulation of Fuel and Fuel Additives

3. General Requirements

3.1 The grades of fuel oil specified herein shall be homogeneous hydrocarbon oils, free from inorganic acid, and free from excessive amounts of solid or fibrous foreign matter.

3.2 All grades containing residual components shall remain uniform in normal storage and not separate by gravity into light and heavy oil components outside the viscosity limits for the grade.

4. Detailed Requirements

4.1 The various grades of fuel oil shall conform to the limiting requirements shown in Table 1. A representative sample shall be taken for testing in accordance with Practice D 4057.

⁴ Annual Book of ASTM Standards, Vol 05.03.

⁵ Annual Book of ASTM Standards, Vol 05.04.

⁶ Available from U.S. Government Printing Office, Superintendent of Documents, 732 N. Capitol St., NW, Mail Stop: SDE, Washington, DC 20401.

4.2 Modifications of limiting requirements to meet special operating conditions agreed upon between the purchaser, the seller, and the supplier shall fall within limits specified for each grade, except as stated in supplementary footnotes for Table 1.

5. Test Methods

5.1 The requirements enumerated in this specification shall be determined in accordance with the following ASTM test methods,⁷ except as may be required under 5.1.1.

5.1.1 *Flash Point*—Test Method D 93 (Procedure A) for Grades No. 1, No. 1 Low Sulfur, No. 2, No. 2 Low Sulfur, and No. 4 (Light), and Test Method D 93 (Procedure B) for Grades No. 4, No. 5 (Light), No. 5 (Heavy), and No. 6, except where other methods are prescribed by law. For Grades No. 1, No. 1 Low Sulfur, No. 2, No. 2 Low Sulfur, and No. 4 (Light), Test Method D 3828 may be used as an alternate with the same limits. For Grades No. 1, No. 1 Low Sulfur, No. 2, and No. 2 Low Sulfur, Test Method D 56 may be used as an alternate with the same limits, provided the flash point is below 93°C and the viscosity is below 5.5 mm²/s at 40°C. This test method will give slightly lower values. In cases of dispute, Test Method D 93, with the appropriate procedure, shall be used as the referee method.

5.1.2 *Pour Point*—Test Method D 97. For all grades, the automatic Test Methods D 5949, D 5950, and D 5985 can be used as alternates with the same limits. In case of dispute, Test Method D 97 shall be used as the referee method. Alternative test methods that indicate flow point properties can be used for

low sulfur residual fuels by agreement between purchaser and supplier.

5.1.3 *Water and Sediment*—The water and sediment in Grade Nos. 1 and 2 shall be determined in accordance with Test Method D 2709 and in Grade Nos. 4, 5, and 6 by Test Method D 95 and Test Method D 473. A density of 1.0 kg/L shall be used for the Test Method D 95 water.

5.1.4 *Carbon Residue*—Test Method D 524.

5.1.5 *Ash*—Test Method D 482.

5.1.6 *Distillation*—Distillation of Grade No. 1 and No. 2 oils shall be determined in accordance with Test Method D 86.

5.1.7 *Viscosity*—Viscosity shall be determined in accordance with Test Method D 445.

5.1.8 *Density*—Practice D 1298. Test Method D 4052 can be used as an alternate with the same limits. In case of dispute, Practice D 1298 shall be used as the referee method.

5.1.9 *Corrosion*—Test Method D 130, 3 h test at 50°C.

5.1.10 *Sulfur*—Test Method D 129 for Grades 1, 2, 4, 5, and 6 and Test Method D 2622 for Grades 1 Low Sulfur and 2 Low Sulfur. Test Methods D 1552, D 2622, and D 4294 can also be used for all grades. In addition, Test Method D 1266 can be used for Grades 1 and 1 Low Sulfur, but only with samples having sulfur contents of 0.4 mass % and less (down to 0.01 %). Test Method D 5453 can be used for Grades 1 and 2 fuel oils, but only with samples having sulfur contents of 0.8 mass % and less (down to 0.001 %). In case of dispute, Test Method D 129 is the referee test method for Grades 1, 2, 4, 5, and 6 of this specification and Test Method D 2622 is the referee test method for Grades 1 Low Sulfur and 2 Low Sulfur.

⁷ For information on the precision of the ASTM test methods for fuel oils refer to "An Evaluation of Methods for Determination of Sulfur in Fuel Oils" by A. R. Crawford, Esso Mathematics and Systems Inc. and G. V. Dyroff, Esso Research and Engineering Co., 1969. This document is available from the Publications Section, API Library, American Petroleum Institute, 1220 L St., NW, Washington, DC 20005.

6. Keywords

6.1 burner fuels; fuel oils; furnace oils; petroleum and petroleum products

APPENDIX

(Nonmandatory Information)

X1. SIGNIFICANCE OF ASTM SPECIFICATION FOR FUEL OILS

X1.1 Scope

X1.1.1 This specification divides fuel oils into grades based upon the types of burners for which they are suitable. It places limiting values on several of the properties of the oils in each grade. The properties selected for limitation are those that are believed to be of the greatest significance in determining the performance characteristics of the oils in the types of burners in which they are most commonly used.

X1.2 Classes

X1.2.1 Because of the methods employed in their production, fuel oils fall into two broad classifications: distillates and residuals. The distillates consist of overhead or distilled fractions. The residuals are bottoms remaining from the distillation, or blends of these bottoms with distillates. In this specification, Grades No. 1 and No. 2 are distillates and the

grades from No. 4 to No. 6 are usually residual, although some heavy distillates can be sold as Grade No. 4.

X1.3 Grades

X1.3.1 *Grades No. 1 and No. 1 Low Sulfur* are middle distillates intended for use in burners of the vaporizing type in which the oil is converted to a vapor by contact with a heated surface or by radiation. High volatility is necessary to ensure that evaporation proceeds with a minimum of residue. The low sulfur grade may be specified by federal, state, or local regulations and can result in reduced deposits on ferrous heat exchanger surfaces compared to Grade No. 1 when burned under similar conditions.

X1.3.2 *Grades No. 2 and No. 2 Low Sulfur* are middle distillates somewhat heavier than grades No. 1 and No. 1 Low Sulfur. They are intended for use in atomizing type burners

which spray the oil into a combustion chamber where the tiny droplets burn while in suspension. These grades of oil are used in most domestic burners and in many medium capacity commercial-industrial burners where ease of handling and ready availability sometimes justify higher cost over the residual fuels. The low sulfur grade may be specified by federal, state, or local regulations and can result in reduced deposits on ferrous heat exchanger surfaces compared to Grade No. 2 when burned under similar conditions.

X1.3.3 *Grade No. 4 (Light)* is a heavy distillate fuel or distillate/residual fuel blend meeting the specification viscosity range. It is intended for use both in pressure-atomizing commercial-industrial burners not requiring higher cost distillates and in burners equipped to atomize oils of higher viscosity. Its permissible viscosity range allows it to be pumped and atomized at relatively low-storage temperatures.

X1.3.4 *Grade No. 4* is usually a heavy distillate/residual fuel blend but can be a heavy distillate fuel meeting the specification viscosity range. It is intended for use in burners equipped with devices that atomize oils of higher viscosity than domestic burners can handle. Its permissible viscosity range allows it to be pumped and atomized at relatively low storage temperatures. Thus, in all but extremely cold weather it requires no preheating for handling.

X1.3.5 *Grade No. 5 (Light)* is residual fuel of intermediate viscosity for burners capable of handling fuel more viscous than grade No. 4 without preheating. Preheating may be necessary in some types of equipment for burning and in colder climates for handling.

X1.3.6 *Grade No. 5 (Heavy)* is a residual fuel more viscous than Grade No. 5 (Light) and is intended for use in similar service. Preheating may be necessary in some types of equipment for burning and in colder climates for handling.

X1.3.7 *Grade No. 6*, sometimes referred to as Bunker C, is a high-viscosity oil used mostly in commercial and industrial heating. It requires preheating in the storage tank to permit pumping, and additional preheating at the burner to permit atomizing. The extra equipment and maintenance required to handle this fuel usually preclude its use in small installations.

X1.3.8 Residual fuel oil supplied to meet regulations requiring low sulfur content can differ from the grade previously supplied. It may be lower in viscosity (and fall into a different grade number). If it must be fluid at a given temperature, Test Method D 97 need not accurately reflect the pour point which can be expected after a period of storage. It is suggested that the purchaser and supplier discuss the proper handling and operating techniques for a given low-sulfur residual fuel oil in the installation where it is to be used.

X1.4 Significance of Test Methods

X1.4.1 The significance of the properties of fuel oil on which limitations are placed by the specification is as follows:

X1.4.1.1 *Flash Point*—The flash point of a fuel oil is an indication of the maximum temperature at which it can be stored and handled without serious fire hazard. The minimum permissible flash point is usually regulated by federal, state, or municipal laws and is based on accepted practice in handling and use.

X1.4.1.2 *Reduced Temperature Properties*—The fuel's

cloud and pour points are good measures for determining low temperature operability with a batch of fuel oil. It is especially important to consider these fuel properties if the heating oil will be subjected to low ambient temperatures at time of use. Fuel temperatures can fluctuate markedly in small, residential, outdoor, above ground tanks compared with indoor, basement tanks, or underground tanks. A decrease or stoppage of fuel flow can occur in small transfer lines used for residential heating applications because the fuel line temperature will fluctuate with ambient temperature faster than will bulk tank contents. Fuel oils purchased during the summer, but not used until the cold heating season arrives, can be a serious source of problems. This is because when these fuels are produced they are intended for use during the warm season and thus typically have higher cloud and pour points than fuels produced for use during the cold season. Fuels can be produced for use at low temperatures with lower cloud and pour points by blending with low paraffin fuels, such as kerosine or No. 1 fuel, and additives, or a combination thereof, to improve low temperature operability. The key to effective treatment is routine monitoring of incoming and stored fuels, and testing of the treated fuels. Although this specification only sets maximum limits for the pour point, the recommendations for cloud point of distillate fuels in Specification D 975 may be applied to heating fuels under extreme cold conditions. Some pipeline companies or local specifications have included requirements for both cloud and pour points for certain grades of fuel oil.

(1) *Pour Point*—The pour point is an indication of the lowest temperature at which a fuel oil is capable of flowing under very low forces. The pour point is prescribed in accordance with the conditions of storage and use. Higher pour point fuels are permissible where heated storage and adequate piping facilities are provided. An increase in pour point can occur when residual fuel oils are subjected to cyclic temperature variations that can occur in the course of storage or when the fuel is preheated and returned to storage tanks. To predict these properties, Test Method D 3245 may be required.

(2) *Cloud Point (Test Method D 2500)*—The cloud point defines the temperature at which a cloud or haze of wax crystals appears in the oil under prescribed test conditions which generally relates to the temperature at which wax crystals begin to precipitate from the oil in use. It is generally observed that cloud point temperature of a fuel oil is higher than its pour point by several degrees Celsius. Fuel oils stored at, or below, their cloud point temperature can have suspended wax crystals that may cause operability problems due to plugging. Examples are when fuels are pumped through small openings or passageways, that is, oil-line filters, burner nozzles, and pump strainers. The plugging is reversible when the fuel is warmed.

X1.4.1.3 *Water and Sediment*—Appreciable amounts of water and sediment in a fuel oil tend to cause fouling of facilities for handling it, and to give trouble in burner mechanisms. Sediment may accumulate in storage tanks and on filter screens or burner parts, resulting in obstruction to flow of oil from the tank to the burner. Water in distillate fuels can cause corrosion of tanks and equipment and it can cause emulsions in residual fuels.

X1.4.1.4 Carbon Residue—The carbon residue of a fuel is a measure of the carbonaceous material left after all the volatile components are vaporized in the absence of air. It is a rough approximation of the tendency of a fuel to form deposits in vaporizing burners, such as pot-type and sleeve-type burners, where the fuel is vaporized in an air-deficient atmosphere.

X1.4.1.4.1 To obtain measurable values of carbon residue in the lighter distillate fuel oils, it is necessary to distill the oil to remove 90 % of it in accordance with Section 9 of Test Method D 524, and then determine the carbon residue concentrated in the remaining 10 % bottoms.

X1.4.1.5 Ash—The amount of ash is the quantity of non-combustible material in an oil. Excessive amounts can indicate the presence of materials that cause high wear of burner pumps and valves, and contribute to deposits on boiler heating surfaces.

X1.4.1.6 Distillation—The distillation test shows the volatility of a fuel and the ease with which it can be vaporized. The test is of greater significance for oils that are to be burned in vaporizing type burners than for the atomizing type. For example, the maximum 10 % and 90 % distilled temperatures are specified for grade No. 1 fuel. The limiting 10 % value ensures easy starting in vaporizing type burners and the 90 % limit excludes heavier fractions that would be difficult to vaporize.

(1) The limits specified for grade No. 2 heating oil define a product that is acceptable for burners of the atomizing type in household heating installations. Distillation limits are not specified for fuel oils of grades Nos. 4, 5, and 6.

X1.4.1.7 Viscosity Limits for Grades Nos. 1 and 2—The viscosity of an oil is a measure of its resistance to flow. In fuel oil it is highly significant since it indicates both the relative ease with which the oil will flow or can be pumped, and the ease of atomization.

(1) Viscosity limits for No. 1 and No. 2 grades are specified to help maintain uniform fuel flow in appliances with gravity

flow, and to provide satisfactory atomization and constant flow rate through the small nozzles of household burners. For the heavier grades of industrial and bunker fuel oils, viscosity is of major importance, so that adequate preheating facilities can be provided to permit them to be pumped to the burner and to provide good atomization. However, it is equally important that the maximum viscosity under the existing conditions be such that the oil can be pumped satisfactorily from the storage tank to the preheater.

X1.4.1.8 Density—Density alone is of little significance as an indication of the burning characteristics of fuel oil. However, when used in conjunction with other properties, it is of value in mass-volume relationships and in calculating the specific energy (heating value) of an oil.

X1.4.1.9 Corrosion—The corrosion test serves to indicate the presence or absence of materials that could corrode copper, brass, and bronze components of the fuel system. This property is specified only for Nos. 1 and 2 distillate fuel oils.

X1.4.1.10 Limited sulfur content of fuel oil can be required for special uses in connection with heat treatment, nonferrous metal, glass, and ceramic furnaces or to meet federal, state, or local legislation or regulations.

X1.4.1.11 Nitrogen—Nitrogen oxide emission regulations have been imposed on certain combustion facilities as a function of fuel nitrogen content. For purposes of these regulations, distillate fuels, low nitrogen residual fuels, and high nitrogen residual fuels have been defined by their nitrogen content. Installations are required to meet different emission standards according to the classification of the fuel being used. When regulations require such a distinction to be made, fuel nitrogen specifications can be needed in the contractual agreement between the purchaser and the supplier.

X1.5 Other

X1.5.1 Microbial Contamination—Refer to Guide D 6469 for a discussion of this form of contamination.

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